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AUTHOR Wells, Stuart
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ABSTRACT

Most analyses of the effectiveness of educational systems or technologies report results in terms of the impact of educational resources on educational outputs, with virtually no attention to the decisions the student may make or the time the student takes to learn the course content. Focusing on the student as an important decision-maker leads to a different model of the educational process, although the typical educational production function is still represented. In this study it was hypothesized that the attendance and studying decisions of the student are affected by the quality of the available educational resources, as well as the initial knowledge and background characteristics of the student. This model was tested using data from a sample of 1,510 first-year economics students at Heriot-Watt University in Scotland. Results of the data analysis clearly showed that students may substitute for inferior educational resources (class, school, media, and teacher) and that these substitutions may result in findings of no significant impact by resources on outputs. By using results from production function studies to allocate educational resources, we may force the student to pay a higher price in terms of his own time.
(Author/JG)

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The Relationship Among Student Decisions, Educational Resources, and Resource Effectiveness

Working Paper 303

Stuart Wells
Visiting Assistant Professor
Faculty of Commerce
University of British Columbia

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Introduction

Most analyses of the effectiveness of educational systems or technologies tend to report results in terms of the impact of educational resources on educational outputs. Background characteristics of the students and other exogenous variables are often included as independent variables in these studies. However, the client of the system, the student, is frequently ignored. Virtually no attention is given to the decisions the student may make or the time the student takes to learn the course content. The lack of attention to the time input of the student is probably attributable to the frequent assertion of a zero opportunity cost to student time based upon the limited job prospects of the student. The lack of employment may be true through the high school level although not through the college level. However, even more important is that this is a restricted view of opportunity costs, i.e., the evaluation of current job prospects. If one takes a longer run view than the opportunity cost of student time may be greater than zero. Reducing the time to learn a course content may reduce the total time of the educational cycle and allow students to enter the job market earlier or on a different level may allow the student to devote more time to other educational activities raising the value of his human capital. Perhaps the lack of attention to student time reflects the pessimistic viewpoint that the educational cycle is of fixed length and change would be difficult to implement or that the content of the curriculum is unimportant

while completion of the curriculum is important.

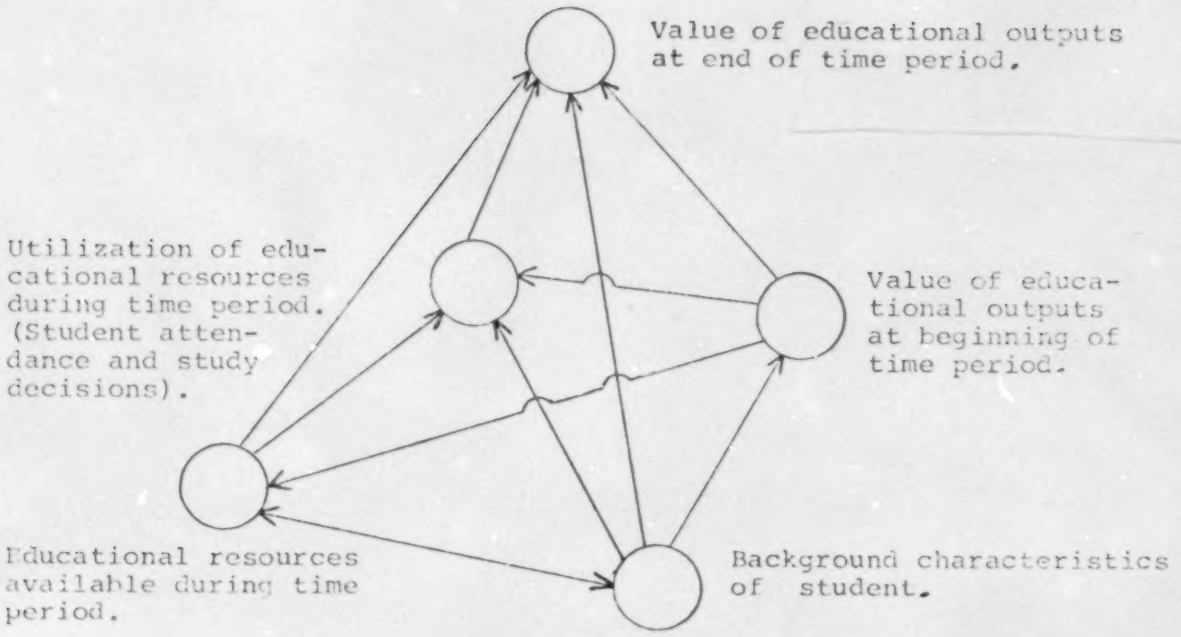
Student time has not been completely forgotten. In their survey of the effectiveness of educational media, Jamison, Suppes, and Wells (1974) cited some studies which reported no significant differences on output scores between conventional classroom instruction and some form of technology but did demonstrate an advantage in terms of reduction in student time for the technology choice. Attiyeh, Bach, and Lumsden (1969) found that students spent three weeks (an average of 12 study hours) to learn the same material as students in a lecture class for seven weeks. Bitzer and Boudreaux (1969) found that the average nursing student completed a course in 50 hours using computer-assisted instruction compared with 84 hours in the lecture.

These studies point to another factor that is frequently ignored, the decision-making on the part of the students. Most studies of education effectiveness involve the student performance on some type of examination; frequently, a final examination at the higher education levels and some type of standardized test at lower education levels. The type of exam is particularly important at the higher education level as the students are being evaluated on this examination in terms of their own course grade. Dubin and Hedley (1969) and Dubin and Taveggia (1968) only included studies of higher education which used a final examination as the evaluative tool. The frequent findings of no significant differences among a variety of instructional techniques in these studies may be attributable to substitution decisions of the students. If the student is

receiving inferior educational resources and he is going to be evaluated on his performance it is only logical to expect the student to compensate for this deficiency by studying more hours and perhaps to 'buy' these hours by attending less frequently. These types of decisions could easily lead to the no significant difference findings and confound our ability to uncover superior instructional techniques or media.

Modeling the Education Process

Focusing on the student as an important decision maker in the educational process leads to a slightly different model of the educational process although the typical educational production function is still represented. By focusing on the student we may say that learning can only take place by an active involvement in the educational process, attendance and studying. It is obviously a simplistic approach to assert that learning requires exposure. We may measure this interaction by the quantity and quality of attendance and studying. The quantity of attendance and studying are in the realm of the student decision making although illness is clearly a random variable which affects these quantities and there may be certain institutional constraints which may influence minimum values on attendance. There is no direct measure of quality of these variables and the best measures of these are the quality of educational resources (class, teacher, school, and media) which were available during the educational period. The diagram below best summarizes this model.


Value of educational outputs at end of time period.
Utilization of educational resources during time period. (Student attendance and study decisions).
Value of educational outputs at beginning of time period.
Educational resources available during time period.
Background characteristics of student.

The educational outputs at the end of the time period (usually a semester or a year) are influenced by the quality and quantity of attendance and studying during the time period. The initial values of the educational outputs and background characteristics of the student also affect the final values of the outputs. In this study our main interest is on the center circle, the attendance and studying decisions of the student. It is hypothesized that these decisions are affected by the quality of the educational resources available to the students, initial knowledge and background characteristics of the student. Random variables such as, illness will be included

in the error term in a regression analysis and institutional constraints are assumed to affect all students equally and not the variability of attendance and studying. As can be seen from the diagram of the model it is a recursive system of equations and as Johnston (1972) has discussed ordinarly least squares regression applied to the separate equations in this type of model will not lead to biased regression results. In this paper the discussion will centre upon the student decisions coordinated with the output results. A more complete discussion of the model and the equations may be found in Wells (1974).

Alternatively we may view the process totally from the viewpoint of the student. The diagrammatic model is for the entire system and includes the determinants of the student decisions without specifying the objectives of the student. Assuming that the student desires to maximize his grade point average (GPA) the following model may be used:

$$\max\ (1)\ GPA = \frac{1}{n} \sum_{i=1}^{n} CG_i;$$

$$(2)\ CG_i = a_i CT_i + b_i ST_i;$$

$$(3)\ CG_i \geq CG_{min};$$

$$(4)\ CG_i \leq CG_{max};$$

$$(5)\ \sum_{i=1}^{n} \left(CT_i + ST_i\right) \leq T_{max};$$

where CG_i is course grade for course i;

CT_i is time spent in class for course i;

ST_i is time spent studying for course i;

a_i is the addition to course grade for one more hour in class for course i;

b_i is the addition to course grade for one more hour of studying for course i;

CG_{max} is the maximum course grade possible;

CG_{min} is the minimum grade which the student must attain in each course;

and, T_{max} is the total time the student will allocate to school-related academic activities.

The linear version of equation (2) is a simplistic representation as the model implies that the student given knowledge of the a_i's and b_i's would only study or attend class in each course depending upon which activity had the higher marginal productivity. Once having net minimum course grades the student would devote time to the activity (attendance or studying in any course) which had the highest marginal productivity and if the course grade maximum was obtained would devote time to the activity with the second highest marginal productivity until his total time (T_{max}) was used or all grades were at the maximum value. A more realistic model would express equation (2) with diminishing marginal productivity. The student would then allocate his time such that $a_i = b_i = c$ for all i (assuming his total time were utilized).

The a_i's are in reality typical educational production

functions for class time while the b_i's may be conceived to be production functions for study time. In both cases the values are functions of student background characteristics and quality of educational resources available for the activities. The study and attendance decisions (CT_i and ST_i) which are examined in this paper are influenced by the marginal productivities of the activities and are also functions of background and resource variables. The production function measures the effectiveness of both activities as it is not possible to perfectly separate the relative contributions of each activity.

Data Source

The data used to test this model was obtained from the Economics Education Project of Heriot-Watt University, Edinburgh, Scotland. The study involved the impact of the first year university economics course in the United Kingdon. The current study involves 1510 students of the 5196 students in the original sample. Missing data (there were no output scores for 2000 of the students) led to this reduction. A variety of test were run and reported in Wells (1974) and it is not expected that this reduction will result in biased results. The British economics course involves the use of large lecture sections and smaller tutorial sections. As these are separate sections the student may make different attendance decisions with respect to the resources he receives in the two sections. In order to gain admittance to a university a student must qualify at the advanced level ('A' level) on an examination for three subjects. Of the students in this study, 552 qualified at the advanced level in economics. The ability to qualify is usually aided by having an advanced level secondary courses.

Results

Table 1 below presents the results of the equations for the students decisions regarding lecture attendance, tutorial attendance, and study hours, and the educational production function for the score on the TEC (Test of Economics Comprehension) a 35 question, multiple-choice examination. The discussion of these results will be concerned with the influence of the educational resources on the decision making of the students and the impact of these resources on the educational output. In terms of background characteristics students with higher pre-test scores, 'A' level economics, higher intelligence scores (AH5 I and AH5 II), and who are male have significantly higher post-test scores. The influence on the attendance and studying decisions is not conducive to any predictable pattern. For example, female students attended more lectures but studied fewer hours than male students. Students with higher intelligence scores tended to attend less often and study less frequently than students with lower scores. Since they are spending fewer hours on the course and receiving higher grades it is possible to assume that the test used is a good measure of intelligence as it relates to economics understanding and that these students are able to substitute innate intelligence for time committment to work.

The rather low values of R^2 for the decision equation of the students means that these results may only tentatively be advanced. However, it is quite logical to assume that the unexplained variability of these decision is largely attributable to illness and other factors which may be unrelated to the quality

of the educational resources available and hence will not bias the regression results.

Class Quality

The more interesting substitution decisions involve the educational resources. Class size is often assumed to be a measure of class quality. The study decisions of the students seem to reflect this assumption. On the average students study 0.01 hours more per week for each additional student in the lecture (average lecture size is 153.9 students) and 0.22 hours more for each additional student in the tutorial section (average tutorial size is 9.6 students). Students in larger tutorial sections also attend less often. If one were only measuring education production functions the results would lead to the confirmation of the assumption that class size cannot be demonstrated to have an impact on output. Tutorial enrollment is not significantly related to output scores and lecture enrollment is significant at the 90% level but the coefficient is rather small so the effect is negligible. As variation in class size can have dramatic impacts on average costs per student the production function equation may well lead one to recommend higher class sizes as a cost-effective measure. However, this analysis reveals that this reduction in financial cost to the institution is born by the students in the increased time they spend on studying.

A hypothesis regarding the number of tutorial sessions and lecture sessions in terms of their quality is hard to formulate. With the significantly smaller enrollment in tutorial sections it

is probably more expensive to offer relatively more tutorial sessions. The results would seem to indicate that a redistribution is favor of more lecture sessions may be in order. Students in courses with more tutorials study more hours and there is no impact on the output score.

The average intelligence level of students in the lecture section may represent a peer group effect. It seems to result in higher test scores and lower lecture attendance. It is hard to interpret these seemingly contradictory effects except to assume that the average intelligence level is another way of representing the intelligence level of the individual student.

The results for the distribution of class time in terms of microeconomics and macroeconomics is also interesting (there are other topics in economics and these two areas do not represent the total possibilities for distribution of class time). Increasing the percentage of either microeconomics or macroeconomics would seem to diminish the test scores indicating some justification for spending more time on other subjects. The students seem to spend more time studying macroeconomics than microeconomics. If one were solely interested in student time this might indicate a redistribution in favor of microeconomics. It may also indicate that students find macroeconomics a more difficult subject and it may be of use to find alternative teaching techniques for these subjects.

Media Quality

Neither of the textbooks or the programmed book seem to affect the output score in relation to the excluded group of textbooks. However, the books seem to have rather dramatic effects on the decisions of the students. Textbook B would seem to be a rather low quality book. Students who were assigned this book attend lectures and tutorials more frequently (4.6% and 5.1% higher attendance rates respectively) and study 2.41 hours more each week than students with other materials. In terms of study time these results are even more dramatic with respect to Textbook A and the programmed book. The results for Textbook A seem to indicate that this book is useful for the basic knowledge of the material but more in-depth discussions are still necessary. This assumes that the tutorial section tends to have more discussions. The results for the programmed book are consistent with other experiments showing no advantage in terms of test scores for students using a programmed book but reduced study time. In this study students using a programmed book studied 1.7 fewer hours per week than students using other texts or media (with the exception of Textbook A for which the advantage is only 0.6 hours).

Teacher Quality

One would expect status of the lecturer and tutor to represent higher quality and average years since last degree (a proxy for experience) to also represent quality. It is not immediately evident what the impact of the instructor's age should

be. However, the results for the educational production function do not reveal that any of these charateristics represent quality in terms of improved test scores. The impact for each of these characteristics for lecturers and tutors is insignificant. As higher status and more experience may also represent increased salaries the logical recommendation to be cost-effective may be to reduce the use of more qualified people for these courses and obtain the same effect for a reduced cost. However, this finding of no significant impact on output scores may well be a result of student substitutions for resources which they feel are inferior. If we examine the student decision equations one observes fairly consistent results. Students with higher status lecturers attend lectures more often and study fewer hours. One must assume that the increased study time of students with lower quality lecturers is sufficient to compensate and the finding of no effect on output score seems reasonable. The students apparently also feel that experience is a quality variable as they attend more often and study less frequently while the age of the lecturer appears to have negative cannotations to the students inducing them to attend less frequently and study more often. In terms of the perception of the quality of the tutor the impact of characteristics is different. Students with higher status tutors study more often and this may indicate that they perceive this as a negative quality in students. More experience for tutors induces less tutorial attendance and less lecture attendance while students with older tutors attend more frequently and study less often. The importance of these results is that they demonstrate very dramatically the impact of the

quality of resources on decision making of the student and that the student is very likely to substitute study time for attendance in situations where he perceives the quality of the resources to be lower.

School Quality and Other Variables

The school quality variables should not be construed to be casual variables but associative variables. For example, students in larger universities do slightly poorer on the examination while students in schools with more economics students do slightly better. It is probably not the age of the school that results in lower learning but other resources and organizational variables that are associated with older schools that may need to be changed. Schools with more economics students may have increased opportunities for students to learn from fellow students. It is also not clear how these variables should impact on the student decisions. It is difficult to explain why more tutors result in decreased lecture attendance and increased study time.

The other variables of importance in the production function equation are the attendance and study time variables. As with the resource variables one would not expect these to be significant given our hypothesis of substitution decisions by the students. No association is expected with these variables as the variation in attendance and studying patterns were assumed to partially relate to the resources the student was receiving. Lecture attendance is significantly related to the test score. This is really not surprising as the variation in resources only explained

a small part of the variation in attendance patterns. The random factor affecting attendance leaves the possibility that increased attendance could result in higher test scores. For example, the student who is ill less often and attends more frequently may well do better on the test.

Conclusions

The main impetus of this paper was an examination of decision making by the students and the relation of these decisions to educational outputs. The results clearly demonstrated that students may substitute for inferior educational resources (class, school, media, and teacher) and that these substitutions may result in many of the findings of no significant impact by resources on outputs. The consequence of using results from production function studies for recommendations regarding allocation of educational resources is that we may be forcing the student to pay a higher price in terms of his own time. Naturally at lower education levels the student is less likely to make these types of decisions regarding the allocation of his time. It should be pointed out that at these lower education levels resources such as, class size (see Jamison, Suppes, and Wells, 1974) are more consistently related to outputs.

An alternative hypothesis regarding the impact of educational resources is that higher quality resources will inspire the students and induce them to expend more time learning the course material. This hypothesis would only be justifiable if we observed positive significant impacts on educational outputs

for educational resources and attendance and studying in the production function equations.

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Table 1

Student Study and Attendance Decisions and Educational Reduction

INDEPENDENT Variables	MEAN S.D.	Dependent Variables: % Lecturers Attended	% Tutorials Attended	Study Hours Per Week	TEC, post-Test
Student Background					
TEC, pre-test (Max. Score = 35)	14.123[a] 4.323	-0.097[b] (1.13)	0.133 (1.54)	-0.021 (0.67)	0.450 (16.60)
'A' Level Econ. (Yes = 1)	0.368 0.502	-1.101 (1.43)	0.187 (0.09)	-0.050 (0.86)	0.798 (3.36)
'A' Level Math (Yes = 1)	0.611 0.686	0.308 (0.87)	0.389 (0.98)	-0.293 (1.78)	0.319 (1.30)
Female Student (Yes = 1)	0.255 0.436	1.814 (2.25)	0.087 (0.02)	-0.794 (3.45)	-0.464 (1.93)
AH5 I (Intelligence Score)	18.285 4.788	-0.108 (1.45)	-0.252 (3.46)	-0.077 (3.56)	0.124 (5.00)
AH5 II (Intelligence Score)	19.841 5.550	-0.133 (1.97)	-0.074 (1.13)	-0.011 (0.65)	0.064 (3.16)
Secondary School (Further Education centers Excluded)					
Independent (Yes = 1)	0.152 0.395	-3.165 (2.04)	-2.750 (1.79)	-1.899 (3.89)	0.261 (0.55)

[a] Mean of variable with standard deviation below.

[b] Regression coefficient of variable with t-statistic of coefficient reported in parentheses

t > 2.58 - Significant at 99%; t > 1.96 - Significant at 95%; t > 1.64 - Significant at 90%

Table 1 (cont'd ...)

INDEPENDENT Variables	MEAN S.D.	% Lecturers Attended	% Tutorials Attended	Study Hours Per Week	TEC, post-Test
Grant-Aid Grammar (Yes = 1)	0.193 0.393	-3.143 (2.14)	-2.087 (1.42)	-1.206 (2.45)	0.183 (0.40)
Local Authority	0.510 0.500	-1.511 (1.12)	-1.865 (1.39)	-1.163 (2.69)	0.061 (0.14)
Secondary Modern (Yes = 1)	0.009 0.095	0.690 (0.04)	-4.569 (1.33)	-2.680 (2.24)	0.176 (0.16)
Compre-hensive (Yes = 1)	0.069 0.254	-1.195 (0.87)	-2.546 (1.12)	-0.858 (1.48)	0.207 (0.38)
Class Quality					
Lecture Enrollment (Number of Students)	193.916 57.488	-0.001 (0.04)	0.013 (1.43)	-0.010 (3.38)	-0.0014 (1.69)
Tutorial Enrollment (Number of Students)	9.604 57.488	-0.008 (0.01)	-0.735 (6.63)	-0.221 (5.78)	-0.050 (0.70)
Number of Lectures (During School Year)	64.055 22.844	-0.028 (1.12)	0.035 (1.42)	0.018 (0.67)	0.005 (0.22)
Number of Tutorials (During School Year)	18.644 9.103	-0.094 (3.85)	0.001 (0.01)	0.098 (4.32)	0.006 (1.31)
Average Intelligence (AH5 I + AH5 II) of Lecture	37.379 3.670	-0.568 (3.55)	0.146 (0.58)	0.053 (0.86)	0.244 (2.13)
% Course Devoted to Microeconomics	41.043 21.194	0.1307 (2.45)	-0.123 (1.12)	-0.062 (3.33)	-0.033 (1.69)

Table 1 (cont'd ...)

INDEPENDENT VARIABLES	MEAN S.D.	% Lecturers Attended	% Tutorials Attended	Study Hours Per Week	TEC, post-Test
Media Quality					
Used Text-book A (Yes = 1)	0.678 0.467	-4.267 (2.67)	3.335 (2.35)	-1.184 (2.37)	0.404 (0.78)
Used Text-book B (Yes = 1)	0.441 0.496	4.687 (2.35)	5.101 (2.67)	2.418 (4.24)	-0.382 (0.68)
Used Pro-grammed Book (Yes = 1)	0.167 0.373	-0.126 (0.01)	5.547 (2.97)	-1.708 (1.54)	0.505 (0.27)
Teacher Quality					
Aver. Charac-teristics of Econ. Faculty					
Status of Lecturer (Scaled Rank 1 to 4)	2.639 0.458	5.560 (4.46)	0.361 (0.16)	-3.041 (6.23)	0.784 (1.14)
Age of Lecturer (Years)	39.429 5.293	-0.620 (2.78)	-0.648 (3.36)	0.296 (3.38)	-0.122 (1.10)
Years Since Last Degree of Lect.	13.522 5.400	0.505 (2.38)	0.573 (3.24)	-0.179 (2.67)	0.001 (0.01)
Status of Tutors (Scaled Rank 1 to 4)	1.987 0.259	-3.078 (1.38)	1.249 (0.67)	1.845 (1.96)	1.221 (0.98)
Age of tutor (Years)	31.370 5.393	0.472 (2.54)	0.260 (1.65)	-0.171 (2.45)	0.157 (1.13)
Years Since Last Degree of Tutor	7.274 4.620	-0.429 (2.24)	-0.527 (2.67)	-0.059 (0.86)	-0.072 (0.40)

Table 1 (cont'd....)

INDEPENDENT Variables	MEAN S.D.	% Lecturers Attended	% Tutorials Attended	Study Hours Per Week	TEC, post-Test
School Quality					
Number of Lectures on Econ. Faculty	4.010 2.339	0.145 (0.67)	-0.303 (1.35)	-0.820 (20.35)	-0.011 (0.07)
Number of Tutors on Econ. Faculty	7.554 4.929	-0.429 (2.33)	-0.066 (0.67)	0.149 (3.69)	0.072 (1.51)
Number of Economics Students (in hundreds)	3.228 1.709	-0.052 (0.01)	0.713 (1.68)	0.035 (0.01)	0.593 (2.73)
Size of University (Hundreds of Years)	1.659 2.035	0.456 (1.68)	0.216 (0.89)	0.171 (1.14)	-0.178 (0.90)
Other					
90 Lectures Attended	90.178 13.396	-	-	-	0.029 (3.59)
90 Tutorials Attended	91.588 12.796	-	-	-	0.005 (0.63)
Number of Study Hours Per Week	4.996 4.539	-	-	-	-0.002 (0.10)
R^2		0.139	0.099	0.307	0.398
Constant		57.047	45.883	1.219	-0.699